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The Impact Effects Knowledgebase: Fast Prediction of the Consequences of NEO Collisions with Earth

Luther, R.[1,2]**, Artemieva, N. A.**[1,3,4]**, Wünnemann, K.**[1,2]**, and Koschny, D.**[5,6]
[1] *Museum für Naturkunde Berlin, Leibniz Institute for Evolution and Biodiversity Science, Invalidenstraße 43, 10115 Berlin, Germany, +49 (0)30 889140 8593, robert.luther@mfn-berlin.de*
[2] *Freie Universität Berlin, Malteserstr. 74-100, 12249 Berlin, Germany*
[3] *Planetary Science Institute, Tucson, AZ 85719-2395, USA*
[4] *Institute for Dynamics of Geospheres, RAS, 119334, Leninprospekt 38, Korpus 1, Moscow, Russia*
[5] *Scientific Support Office, Directorate of Science, European Space Research and Technology Centre (ESA/ESTEC) 2201 AZ Noordwijk, The Netherlands*
[6] *LRT / TU Munich, Boltzmannstraße 15, D-85748 Garching, Germany*

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ABSTRACT

Near-Earth-Objects down to the size of some tens of metres are potentially most hazardous as they occur much more frequent than larger objects but they are still big enough to cause significant damage if they hit in populated and, thus, vulnerable regions on Earth. Simulation tools, so-called shock-physics codes or hydrocodes, allow for detailed quantitative modelling of the processes during the atmospheric travers, the potential break-up and impact on the ground of cosmic bodies ranging from a few meters up to 100m. Such simulation tools that may be considered as

“research-class” tools, provide more or less accurate predictions of the environmental consequences but have high demands on computing resources and often need several days, weeks or up to months of computation time. On the other hand, so-called “emulation-class” tools use simplified dependencies (empirical parameterisations and scaling laws) to estimate the effects of an asteroid encounter with Earth. Although they give results quickly, they are often not reliable enough in their predictions. A tool that is accurate enough to allow good predictions of the effects of an asteroid collision, is easy to use and gives results quickly, i.e. in a maximum of a few minutes of computation time, is highly desirable for ESA’s SSA-NEO segment to release impact warnings and inform emergency response agencies.

The goal of this study is to develop what we call an “operation-class” tool that combines accurate modelling predictions with fast predictions within a short time frame after detection of a hazardous object on an Earth crossing trajectory. Our approach is based on a knowledge-base that comprises “emulation-class” tools (parameterisations and scaling laws) and results from systematic full-scale modelling studies that are stored in a database. As input parameters that define the dimension and extent of the knowledge base we use: impact velocity, impact angle, impactor size, and impactor material properties. The properties of the impactor are considered by two iron and three stony types each of which represent typical objects.

In a first step, the impact scenario is simulated by “emulation-class” tools (e.g. pancake model or the separate fragment model), which will take no longer than seconds or minutes. Previous benchmark studies and comparisons with real events (e.g. Chelyabinsk, Tunguska) will allow for an assessment of the expected accuracy of such a first order estimate. If the accuracy is rated as not sufficient, previously conducted full-scale models (research-class tools) that are most similar to the given impact scenario will be identified and used for interpolation of the outcome. As output parameters we intend to provide: the energy release at a given altitude in the atmosphere, and overpressures, wind speeds, and the irradiation at the ground. In the case of a cratering event, we estimate the size of the crater and the ejecta blanket.

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